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CHLORDANE IN AIR FORCE FAMILY HOUSING:
A STUDY OF HOUSES TREATED AFTER CONSTRUCTION

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Airborne chlordane levels were measured in 474 family housing units on seven USAF installations during the winter of 1980-81. The ventilation ducts were in or below the slab in 469 houses and in the crawl spaces in 5 houses. All were treated with chlordane by subslab injection or exterior ditching at some time after construction. Four hundred eight houses (86%) had chlordane levels below 3.5 $\mu\text{g}/\text{m}^3$, 56 houses (12%) had levels from 3.5-6.5 $\mu\text{g}/\text{m}^3$, and 10 houses (2%) had levels above 6.5 $\mu\text{g}/\text{m}^3$. There was no correlation between the (over)		

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cont concentration of airborne chlordane and inside or outside temperature, barometric pressure, relative humidity, or the difference between inside and outside temperature. Houses with exhaust ducts in or below the slab did not have significantly higher levels of airborne chlordane than houses with return air ducts in that location.

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I. BACKGROUND SUMMARY

Chlordane (1,2,4,5,6,7,8,8 octochloro-2,3,3a,4,7,7a-hexahydro-4,7 methanoindene and related compounds) was first developed in 1945 (Kearns et al. 1945). It was widely used in the U.S. for agricultural and household pest control until 1975 when the Environmental Protection Agency (EPA) restricted its use to termite control and the dipping of roots and tops of certain nonedible plants (EPA 1976). The restriction was justified by the high persistence of chlordane in the environment, its degradation to heptachlor epoxide, and the discovery of degradation products in food, human tissue, and in wildlife. The EPA cited results of experiments with rats and mice showing significant increases in cancerous tumors caused by the breakdown product heptachlor epoxide. The tumors were found in several organs of these experimental animals, including the liver and other endocrine glands. There was also evidence indicating that heptachlor epoxide in humans is transferred from the mother to the fetus across the placenta (EPA 1974). A more recent study by the National Cancer Institute concluded that chlordane concentrations of 40 parts per million (ppm) and higher in the feed of mice caused a significant increase in liver cancer (NCI 1977).

The discovery of chlordane residues in food, human tissue, and in wildlife was a clear indicator of human exposure to the compound. Market basket samples purchased from retail stores by the Food and Drug Administration in five U.S. regions over a six and one-half year period revealed heptachlor epoxide to be common in dairy, meat, fish, and poultry products. The pesticide residues could enter the human body when such foods are ingested and, being fat soluble, would be stored in fatty tissue. Human monitoring studies in the U.S. showed chlordane metabolites in the fatty tissue of more than 90% of several thousand hospital patients studied in 1970 through 1972 (EPA 1974). Chlordane residues have also been found in human milk (Miyazaki et al. 1980; Savage et al. 1981).

The only epidemiological data available on human exposure to chlordane were collected in an occupational exposure setting. An examination of workers exposed to 1.2 to 1.7 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) for 1-15 years showed no job-related illness among the workers (Fishbein et al. 1964). A similar conclusion was given following a study of workers exposed to 5,000 $\mu\text{g}/\text{m}^3$ for three years (Princi and Spurbeck 1951). Exposure to higher concentrations for prolonged periods have resulted in blurred vision, cough, confusion, ataxia, and delirium (Barnes 1967; Selby and Jones 1960). A statistical evaluation of death records for individuals employed in the manufacture of chlordane noted a significant excess of deaths from cerebrovascular disease, but the researchers emphasized that this should not be accepted as evidence of a consequence of exposure to chlordane without further study (Wang and MacMahon 1979).

A continuous exposure level of 500 $\mu\text{g}/\text{m}^3$ is the maximum allowable limit in an occupational setting (8 h/day, 5 days/week) (ACGIH 1981). This value is unacceptable in the home environment because of the potential for 24 h/day exposure of newborn, sick, elderly, or pregnant individuals. The National Academy of Sciences (1979) recommended a level of 5 $\mu\text{g}/\text{m}^3$ as acceptable in the home but, in doing so, the Academy stated that it "...could not determine a level of exposure to chlordane below which there would be no biological effect under conditions of prolonged exposure of families in housing." The question of chronic exposure is difficult to assess because persons are exposed to chlordane from a variety of sources.

Airborne chlordane contamination has been reported in Air Force (Callahan 1970), Army (Vinopal and Olds 1977) and civilian (Malina et al. 1959) houses following treatment for termites. Contamination has occurred in newly constructed houses that were pretreated (unpublished data) as well as in older houses treated by subslab injection (Callahan 1970). In all cases, the ventilation system was in close proximity to the treated soil. Savage (1975) studied the problem in houses with forced air plenum distribution systems; Wright and Leidy (personal communication) studied houses with crawl space construction; and the Air Force has conducted extensive tests in houses with ventilation ducts in or below the slab (Callahan 1970; Livingston et al. 1981). The highest airborne concentration detected in a housing unit is 1,580 $\mu\text{g}/\text{m}^3$, but this resulted after 15 gallons of a 2% chlordane solution were injected directly into a subslab duct (Callahan 1970). The majority of houses (96%) have levels below 5 $\mu\text{g}/\text{m}^3$ (Livingston et al. 1981).

Various methods have been examined for correcting houses with unacceptable levels. Callahan (1970) suggested replacing the ducts or cleaning the ducts with trichloroethylene (TCE). The latter method was abandoned because the TCE would seep into the soil and could not be retrieved when the ducts were below the slab. Replacing the ducts was effective, but did not eliminate the hazard when subsequent treatment for termites was required. Callahan (1970) and Livingston et al. (1981) reported that modifying the construction design by sealing the subslab ducts and installing new furnaces and ceiling ducts would significantly reduce the airborne chlordane level. This method would also allow future treatment for termites by subslab injection without contaminating the ventilation system. Callahan (1970) also reported that as much as 90% of the chlordane residue can be removed from floors, walls and ceilings by scrubbing these surfaces with a solution of methanol and water.

Reports of airborne chlordane in family housing and a lack of information concerning its impact on human health prompted action by several government organizations. The EPA is preparing a risk/benefit analysis of several chemicals registered for termite control; the Armed Forces Pest Management Board has requested that the Armed Forces Epidemiology Board evaluate the hazard associated with various termiticides; and the Department of Defense (DOD) issued guidelines for all military services to follow in the assessment and abatement of airborne chlordane contamination of family housing [Safety and Occupational Health Program Policy Memorandum (SOHPPM 81-2, 1981)]. According to the DOD plan, the services must conduct an inventory of termiticide-treated buildings with sub- or intraslab heating or cooling ducts, sample each building to determine the airborne termiticide level, and take corrective action in houses which exceed the action level.

The USAF Occupational and Environmental Health Laboratory, at the request of the AF Medical Service Center, planned and coordinated a chlordane sampling program in 474 houses on seven USAF installations (Arnold, Chanute, Laughlin, McConnell, Mt Home, Sheppard, and Vance) during the winter of 1980-81. All houses were treated with chlordane by subslab injection or exterior ditching at some time after construction. The houses at McConnell AFB had ventilation ducts in the crawl space while all houses at the remaining installations had ventilation ducts in or below the slab.

II. MATERIALS AND METHODS

One air sample was collected and analyzed from each of 474 houses in accordance with guidelines found in the attachment (Appendix 1) to DOD SOHPPM 81-2 (15 Jul 81). Analytical results were reported as μg of chlordane/sample. The lower detection limit was $0.2 \mu\text{g}/\text{sample}$. Analytical results were converted to $\mu\text{g}/\text{m}^3$ to indicate airborne exposure levels. Since sample volumes varied between houses, the lower analytical detection limit, once converted, ranged from 0.4 - $0.6 \mu\text{g}/\text{m}^3$. Inside temperature and relative humidity were recorded when the sampling equipment was set up. The installation weather service was contacted at the end of each day to obtain hourly (on the hour) readings of outside temperature and barometric pressure. The data were subjected to analysis of variance, stepwise regression, Pearson's correlation and Spearman's correlation.

III. RESULTS AND DISCUSSION

The number of houses with airborne chlordane levels above the detection limit varied considerably between installations. At one installation, with sub- or intraslab ducted houses, 98% of the houses had levels above $0.6 \mu\text{g}/\text{m}^3$ while only 15% of the houses at another installation exceeded that level (Table 1). Houses at the latter installation were treated from the interior by injecting chlordane vertically under the slab, whereas the application equipment was inserted laterally from the exterior at the former installation. Lateral injection from the exterior may have resulted in a greater amount of chlordane dispersed on a lateral plane in proximity to the slab, thereby increasing the probability of chlordane contact with the intra- or subslab ducts. If so, difference in method of treatment might have contributed to the above noted difference in the percentage of houses having levels above the detection limit. Future studies should further investigate whether the method of application does in fact significantly affect airborne chlordane levels.

Table 1. Number of houses with airborne chlordane levels within four concentration ranges ($\mu\text{g}/\text{m}^3$) and the total number sampled at each installation.

INSTALLATION	≤ 0.6	0.7-3.4	3.5-6.5	> 6.5	TOTAL
Arnold	10	28	2	0	40
Chanute	5	6	0	1	12
Laughlin	46	7	7	0	100
*McConnell	0	3	2	0	5
Mt Home	56	6	2	2	66
Sheppard	9	11	1	0	21
Vance	4	177	42	7	230
Total	130	278	56	10	474
%	27	59	12	2	

*All houses had ventilation ducts in the crawl space

When the results from all installations were pooled, the airborne chlordane level exceeded $0.6 \mu\text{g}/\text{m}^3$ in 73% of the houses sampled (Table 1). A similar percentage was reported by Livingston et al. (1981) based on a study of 498 houses at a midwestern AFB. Four hundred and eight houses (86%) had chlordane levels below $3.5 \mu\text{g}/\text{m}^3$, 56 houses (12%) had levels from 3.5 – $6.5 \mu\text{g}/\text{m}^3$, and 10 houses (2%) had levels above $6.5 \mu\text{g}/\text{m}^3$. According to current guidance in DOD SOHPPM 81-2 (15 Jul 81), the 10 houses exceeding $6.5 \mu\text{g}/\text{m}^3$ require corrective action, the 56 houses between 3.5 and $6.5 \mu\text{g}/\text{m}^3$ require additional sampling, and the remaining 408 houses do not require immediate attention.

The route of air circulation was not the same in all houses sampled due to design differences. In most houses, exhaust ducts (warmer air release) were in or below the slab and return ducts (cooler air return) were located in the ceiling. The situation was reversed, however, in 140 houses. Air temperature in the exhaust ducts during heater operation approaches and may exceed 50°C whereas air entering the return ducts is much closer to room temperature (21 – 27°C). As a consequence, temperatures in slab and subslab ducts would be considerably higher where these ducts carried air from the heater. Since the vapor pressure of a 1% emulsifiable chlordane solution increases markedly with temperature, a higher concentration of airborne chlordane might be expected in houses with exhaust ducts in or below the slab, but no such correlation was indicated.

Only five houses with crawl space construction were sampled. The return air ducts were located in the crawl spaces. The airborne chlordane level exceeded $1 \mu\text{g}/\text{m}^3$ in all houses and two of the five houses had levels $\geq 5 \mu\text{g}/\text{m}^3$ (Table 1). Concentrations of 6 to $40 \mu\text{g}/\text{m}^3$ were measured during an earlier study of chlordane in the air of houses with crawl spaces (Malina, 1959). Further study should be conducted to determine the route of entry of chlordane into the living area and to determine the extent of airborne chlordane contamination in Air Force family housing with ventilation ducts in the crawl spaces.

The inside temperatures ranged from 14 – 29°C ; barometric pressures ranged from 27.1 to 30.0 inches of mercury (uncorrected); outside low temperatures were -11 to 21°C ; outside high temperatures were -11 to 22°C ; and inside relative humidities ranged from 14 to 86% . There was no correlation between airborne chlordane concentration and inside temperature, relative humidity, barometric pressure, outside high temperature, outside low temperature or time of day of sampling. Absence of these correlations agree with results previously reported by Livingston et al. (1981).

The difference between inside temperature and outside low temperature during the sampling period also was calculated for each house. It was assumed that the duration of heater operation increased as this temperature difference increased. A greater volume of warm air would flow through the ducts in houses with increased heater operation. A higher airborne chlordane level would be expected but there was no correlation between airborne chlordane concentration and the temperature difference.

IV. CONCLUSIONS

A. There was no correlation between the concentration of airborne chlordane and inside or outside temperature, barometric pressure, relative humidity, or the difference between inside and outside temperature.

B. Houses with exhaust ducts in or below the slab do not have significantly higher levels of airborne chlordane than houses with return air ducts in that location.

C. The airborne chlordane level in houses with ventilation ducts in the crawl space can also exceed the 5 $\mu\text{g}/\text{m}^3$ action level.

V. RECOMMENDATIONS

A. Further sampling should be conducted at other installations with sub- or intraslab ducted dwellings to determine the extent of airborne chlordane contamination in family housing.

B. Future studies should further investigate whether the method of application does in fact significantly affect airborne chlordane levels.

C. Further study should be conducted to determine the extent of airborne termiticide contamination in houses with ventilation ducts in the crawl space.

REFERENCES CITED

- American Conference of Governmental Industrial Hygienists. 1981. TLVs Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1981. ACGIH, Cincinnati, Ohio.
- Barnes, R. 1967. Poisoning by the insecticide chlordane. Med. J. Aust. 1:972-973.
- Callahan, R.A. 1970. Chlordane contamination of government quarters and personal property. USAF Environmental Health Laboratory/Kelly AFB TX. Tech Rep. 70-7. 75 pp.
- DOD. 1981. Chlordane in Department of Defense Buildings. Safety and Occup. Hlth. Prog. Policy Memorandum 81-2 (15 Jul 1981) 16 pp.
- EPA. 1974. EPA issues notice of intent to cancel two pesticides, heptachlor and chlordane. Environ. News 19 Nov 1974:4 pp.
- EPA. 1976. Velsicol Chemical Co. et al. Consolidated heptachlor/chlordane hearing. Fed. Reg. 41:7552-7585.
- Fishbein, W.I., J.V. White, and H.J. Isaacs. 1964. Survey of workers exposed to chlordane. Indus. Med. Surg. 33:726-727.
- Kearns, C.W., L. Ingle, and R.L. Metcalf. 1945. A new chlorinated hydrocarbon insecticide. J. Econ. Entomol. 38:661-668.
- Livingston, J.M., C.R. Jones, and T.H. Lillie. 1981. Airborne chlordane contamination in houses treated for termites at a midwestern Air Force base. USAF Occupational and Environmental Health Laboratory Tech Report 81-11. 34 pp.
- Malina, M.A., J.M. Kearny, and P.B. Polen. 1959. Determination of chlordane in air of habitations tested for insect control. J. Agri. Food Chem. 7:30-33.
- Miyazaki, T., K. Akiyama, S. Kaneko, S. Horii, and T. Yamagishi. 1980. Chlordane residues in human milk. Bull. Environ. Contam. Toxicol. 25:518-523.
- National Academy of Sciences Committee on Toxicology. 1979. Chlordane in Military Family Housing. 10 pp.
- National Cancer Institute, 1977. Bioassay of chlordane for possible carcinogenicity. DHEW Publ. No. (NIH) 77-808:117 pp.
- Princi, F. and G.H. Spurbeck. 1951. A study of workers exposed to the insecticides chlordan, aldrin, dieldrin. Arch. Ind. Hyg. Occup. Med. 3:64-72.

- Savage, E.P. 1975. Pesticide residues in houses utilizing forced air plenum distribution systems. Report of the Colorado Epidemiological Pesticide Studies Center. 72 pp.
- Savage, E.P., J.J. Keefe, J.D. Tessari, H.W. Wheeler, F.M. Applehans, E.A. Goes, and S.A. Ford. National study of chlorinated hydrocarbon insecticide residues in human milk, USA. I. Geographic distribution of dieldrin, heptachlor, heptachlor epoxide, chlordane, oxychlordane, and mirex. Am. J. Epidem. 113:413-422.
- Selby, G. and A.T. Jones. 1960. Chlordane poisoning following prolonged use for ant control at a private home. Med. J. Aust. 1:417-419.
- Vinopal, J.H. and K.L. Olds. 1977. Investigation of suspected nonoccupational human intoxication/chlordane termite treatment Fort Monmouth NJ. U.S. Army Environ. Hyg. Agency Pesticide Monitoring Special Study No. 44-0957-77. 17 pp.
- Wang, H.H. and B. MacMahon. 1979. Mortality of workers employed in the manufacture of chlordane and heptachlor. J. Occupat. Med. 21:745-748.

SAMPLING AND ANALYSIS

FOR

CHLORDANE IN AIR

(From DOD SOHPPM 81-2)

Appendix I

INTRODUCTION

Chlordane is a chlorinated hydrocarbon insecticide similar to aldrin, dieldrin, endrin, and heptachlor. It was first used in the United States for agricultural and household pest control in 1945. Control of pests on nonfood crops such as cotton and lawn grasses was the primary agricultural application. It has also been used for controlling the imported fire ant in several southern states. Use of chlordane in the home was limited initially to cockroach, fly and termite control.

In December 1975, the Environmental Protection Agency (EPA) suspended most uses of chlordane in the United States. The suspension was justified by the high persistence of chlordane in the environment, its degradation to heptachlor epoxide, and the discovery of degradation products in food, human tissue, and in wildlife. Persistence is an attribute of many chlorinated hydrocarbons. Approximately 20% of originally applied chlordane dosages are recoverable in soil ten years after application. The probability for exposure of organisms to chlordane is greatly increased by its persistent nature. Insecticide persistence also increases the chance for bioaccumulation and biomagnification in organisms.

The EPA cited the results of experiments with rats and mice showing significant increases in cancerous tumors caused by heptachlor epoxide. The tumors were found in several organs of these experimental animals, including the liver and the endocrine glands. Human exposure to heptachlor epoxide was clearly indicated by residues in food, human tissues, and wildlife.

Chlordane application for fire ant control was suspended in December 1980. Subterranean termite treatment and the dipping of roots or tops of nonfood plants are the only remaining registered uses for chlordane. The EPA is presently investigating the efficacy and hazards of chlordane and other termite control agents.

Three different methods have been practiced for applying chlordane (1% active ingredient) for termite control. The first method is to treat the soil prior to house construction. This produces a barrier between the slab and the soil. Control could be achieved for 10 - 12 years after application. A second method is to dig a trench around the perimeter of the slab, pour a solution of chlordane into the trench, and allow the material to seep into the soil. This method forms a barrier to prevent lateral movement of termites under the house but may not kill those under the slab at the time of application. The trench method is often used in conjunction with the first method to achieve the best control possible with chlordane. When an existing house is infested with termites, a third method called subslab injection can be used. Holes are drilled through the floor of the house and a high pressure system is used to pump chlordane into the soil beneath the slab. This method is effective and widely used; however, problems have occurred in houses with heating ducts in or below the slab. The chlordane has been injected directly into the heating ducts in some cases or it has leached through the soil into the ducts in other instances. The chlordane in the duct was dispersed into the air of the house when the heating system was activated.

The purpose of this protocol is to establish a systematic method of evaluation of airborne chlordane levels in family quarters. The sampling and analytical procedures were developed by the USAF Occupational and Environmental Health Laboratory, Brooks AFB, Texas.

PROCEDURES*

A. Equipment

1. Vacuum pump with adjustable flow capable of maintaining a flowrate of 4 liters per minute (Millipore part number XX6100000, 115 volt, 60Hz, pressure vacuum pump has proven very dependable).
2. Precision rotameter
3. Chromosorb 102 sampling tubes (SKC Corp part number 226-49-102)
4. Tygon tubing
5. Sling psychrometer
6. Deionized water (for sling psychrometer)
7. Wire clipper (for breaking ends off Chromosorb tubes)
8. Gummed labels and waterproof markers
9. Data sheets (sample data sheet at Atch 1). Each data sheet should be sequentially numbered.

B. Preparation

1. Calibrate the portable precision rotameter using a bubble meter in the laboratory prior to use in the field. Correct readings to standard temperature/pressure equivalents. Record rotameter values for 3 liters/minute through 5 liters/minute for later use in the field.
2. Obtain a list of houses which require sampling, the date each house was treated for termites and the method of treatment (i.e., subslab injection, exterior ditching, soil treatment prior to construction).
3. Notify the appropriate installation personnel of dates when houses will be sampled. Provide the hospital/clinic commander or environmental health officer with chlordane history and toxicology information. The Introduction section of this protocol can serve as a basis for this fact sheet. The installation commander should inform housing occupants of the sampling program. A suggested letter is supplied at Atch 2 for this purpose. It is not necessary to send the letter to all occupants, but rather only to those whose houses will be sampled.
4. Obtain a list of home phone numbers for the occupants of all houses to be sampled. This will require coordination through the installation commander and housing officer.

*NOTE: All sampling should be conducted during winter months to ensure evaluation of "worst-case" conditions.

5. Arrange for vehicles to be used by persons collecting samples. Each sampling team will need one vehicle.

C. Sampling Occupied Houses

1. One individual should work as scheduler. He should contact each occupant by telephone to obtain entry authorization and establish sampling time. The occupant should be reminded that the sampler will run for two hours. The scheduler should be well informed of the history, use and toxicology of chlordane because the occupants will ask questions. Houses should be scheduled 24 to 48 hours in advance of the date of sampling.

2. Each sampling team should consist of two personnel. One individual should record data and answer questions from the occupant while the other sets up the sampling equipment.

3. Place the vacuum pump on the floor near an incoming heater vent (as opposed to a return air vent), preferably in the living room. Open both ends of a Chromosorb 102 tube and attach to the vacuum pump so that the arrow on the tube points in the direction of the air flow. Position the vacuum pump so that the collection tube hangs over the air vent. Turn the pump on and adjust the flowrate to 4 liters/minute using the rotameter. Tap tube lightly with pencil or pen to compact collecting media. This prevents possible channeling effects. The pump should run unattended for two hours. Do not adjust the heater thermostat; simply collect the sample under existing conditions used by the occupant. Use the sling psychrometer to determine dry bulb and wet bulb temperatures in each house at the time the pump is set up. Record the following data on the data sheet.

- a. Date collected
- b. Sample location: living room, kitchen, or bedroom
- c. House number and street
- d. Pump number
- e. Time the pump is turned on
- f. Rotameter reading when pump flowrate is set
- g. Sling psychrometer wet and dry bulb readings
- h. Name of individual collecting the sample
- i. Collection medium: Chromosorb 102
- j. Base/installation name
- k. Note any unusual petroleum-like odor, if present, in the remarks section. Chlordane itself is odorless but the odor of the oil base carrier

can often be detected when the airborne chlordane concentration is greater than approximately 10 micrograms per cubic meter.

4. After two hours take a second rotameter reading (do not adjust the flowrate), turn off the pump, and record the following:

- a. Rotameter reading
- b. Time the pump was turned off

c. Sample number consisting of an installation code, house number, and data sheet number. For example, a sample collected on McConnell AFB at 1945 Jupiter St and recorded on data sheet number 000002 would have the following sample number: MC1945000002.

5. Remove the Chromosorb 102 tube from the pump and place closure caps securely on the ends of the tube. Write the sample number on a gummed label with a waterproof marker. Wrap the label around the middle of the tube so that two gummed surfaces adhere to one another.

6. Pick up pumps and Chromosorb tubes and record data from other houses in the same order the pumps were set up.

7. At the end of the sampling day, obtain readings of hourly (on the hour) ambient temperature ($^{\circ}\text{F}$) and uncorrected barometric pressure. The data should be available from the installation weather service. If such service is not available, arrangements should be made to collect the data or to obtain it from the National Weather Service.

8. The samples are highly stable: they need not be refrigerated during storage.

9. Complete data sheet by entering the following:

- a. Determine percent relative humidity from wet and dry bulb measurements
- b. Ambient temperature (high and low) and uncorrected barometric pressure during the sampling period
- c. Sampling time: number of minutes the pump was on
- d. Average flowrate during sampling time in liters/minute
- e. Total air volume (m^3): calculated by multiplying the average flowrate (liters per minute) X sampling time (minutes) and dividing by 1,000.

D. Sampling an Unoccupied House

1. Obtain entry authorization from the base housing officer. Set heater thermostat to 72°F . Open one window in each room of the house so that a 2 inch open space exists for air flow. The house should remain in this

condition for 72 hours prior to collecting the sample and during the sampling period. The purpose of the open windows is to simulate traffic into and out of an occupied house.

2. Collect the sample in the manner described in C-3 through C-9.

E. Quality Control/Quality Assurance Samples: Four types of samples should be used to verify the reliability of the sampling and analytical procedures.

1. Control Sample: A sample collected in the same manner as a routine sample but from a house with no history of chlordane treatment. Such a house is often difficult to locate with certainty; hence, this may be eliminated from the quality control plan. If possible, collect one or two control samples from each installation where a sampling program is conducted.

2. Blank Sample: A tube which is simply opened and immediately capped. This procedure is performed in a house where a routine sample is collected. Each sampling team should submit one blank sample each sampling day. The blank is labeled in the same manner as other samples, but with a house number that would not occur on that installation. Enter the word BLANK on the sampler location line of the data sheet.

3. Dummy Sample: A tube which is capped without being opened. One dummy sample should be submitted for analysis from each lot of Chromosorb 102 tubes. The dummy is labeled in the same manner as other samples, but with a house number that would not occur on that installation. Enter the word DUMMY on the sampler location line of the data sheet.

4. Spiked Sample: A tube which has been injected with a known concentration of chlordane in a chemical laboratory. The quantity should be in the range expected in a house, 1 to 10 micrograms of chlordane. The number of spiked samples should be approximately 2 to 5% of the total number of samples being analyzed.

F. Analytical Procedures. Procedures for analysis of air samples collected using Chromosorb 102 and ethylene glycol are included in F6 below, as well as procedures for analysis of swabs collected to assess surface contamination. The method used to determine chlordane in these materials is very similar to the technique used for chlorinated hydrocarbons in water. Differences are in the area of preliminary preparation of the samples, use of one gas chromatograph glass column instead of the usual two, and concentration of the sample in a vacuum rotary flash evaporator concentrator rather than the standard Kuderna-Danish apparatus. These changes were instituted to speed up analysis time of the samples.

1. Reagents

- a. Hexane distilled in glass, pesticide analysis grade
- b. Granular anhydrous Na_2SO_4
- c. Woelm neutral alumina

- d. Organic-free distilled water
- e. Acetone distilled in glass, pesticide analysis grade
- f. Ethylene glycol, pesticide analysis grade

2. Equipment and Glassware

- a. Varian Aerograph HY-FI III, Model 1200, with a proportional temperature programmer, or similar instrument, with electron capture detector.
- b. Recorder, 0-1mV, half inch per minute or equivalent.
- c. Hewlett-Packard 3352B Laboratory Data System.
- d. Blackstone Ultrasonic vibrator.
- e. Calab rotary vacuum flash evaporator-concentrator.
- f. Laboratory glassware.

(1) All glassware, except volumetric glassware, is heated to 300°C for eight hours to eliminate organic contamination, after detergent washing and rinsing in acid water (pH less than 2) and rinsing clean of the acid with organic free water.

(2) Volumetric glassware is cleaned with sodium dichromate in concentrated sulfuric acid cleaning solution, rinsed clean of sodium dichromate with organic-free water, rinsed with nanograde acetone, (distilled in glass), rinsed in distilled water, and dried in an oven.

3. Column Preparation: DC-200 silicone grease is coated 2.5 percent by weight on 60/80 mesh Gas-Chrom Q. The material is also coated with 0.25 percent Carbowax 20M, and packed into a 1.5 mm-ID, 3 mm-OD heat resistant glass column, 6 feet long.

4. Preparation of Standards

a. Concentrated Stock Standard Solution: Weigh 30 milligrams of chlordane standard (chlordane Lot 1001 obtained from Beckman Instruments) and dilute to 100 ml with hexane in a volumetric flask (300 micrograms per ml).

b. Intermediate Standard (3 micrograms per ml): Pipet 1 ml of the concentrated standard (300 micrograms/ml) and dilute to 100 ml in a volumetric flask.

c. Working Standard (300 picograms per microliter): Pipet 10 ml of the intermediate standard (3 micrograms/ml) and dilute to 100 ml in a volumetric flask.

5. Procedure: The three types of samples received for analysis of chlordane (cotton swabs, chromosorb air samples, and ethylene glycol air samples) are prepared individually as follows and then are all analyzed alike after the point of vacuum rotary flash evaporation-concentration.

a. Cotton Swabs

(1) The cotton swabs are saturated in the sample container with approximately 100 ml hexane and mixed in an ultrasonic vibrator for 20 minutes.

(2) Quantitatively decant hexane into a filter funnel containing a glass fiber filter with a small amount of anhydrous sodium sulfate (to remove moisture) into a 500 ml round bottom flask. Suck swab as dry as possible with disposable micro pipette. Rinse swabs twice with approximately 50 ml hexane, stirring thoroughly, and transfer to funnel. Rinse funnel thoroughly. Concentrate sample in flash evaporator to 0.5 ml. Add sufficient hexane to obtain a 5 ml final volume.

b. Chromosorb-102 Air Samples

(1) The sample tubes are scored with a file, broken, and the contents transferred into an Erlenmeyer flask with 50 ml hexane. Rinse both sides of tube thoroughly with hexane. Mix and place flask in vibrator for 30 minutes.

(2) Quantitatively decant hexane and chromosorb into a 500 ml round bottom flask through a filter funnel containing a glass fiber filter with a small amount of anhydrous sodium sulfate (to remove moisture). Rinse the Erlenmeyer flask thoroughly with three 10 ml portions of hexane. Rinse funnel thoroughly. Concentrate sample to 0.5 ml, using a vacuum rotary flash evaporator-concentrator. Add sufficient hexane to obtain a 5 ml final volume.

c. Ethylene Glycol

(1) Quantitatively transfer ethylene glycol to a separatory funnel. Rinse sample container well with organic-free distilled water. Add 400 ml organic free water. Add 50 ml hexane, stopper, and shake funnel vigorously for two minutes. Allow a few minutes for phase separation. Separate hexane phase (top layer) and reextract the aqueous phase two more times with 25 ml portions of hexane. Collect all hexane fractions in a clean separatory funnel. Add 50 ml of organic-free water to the hexane, stopper, and shake vigorously one minute. Discard aqueous layer and repeat extraction with another 50 ml of water. Separate and discard aqueous phase.

(2) Quantitatively transfer hexane through a filter funnel containing a glass filter with a small amount of anhydrous sodium sulfate (to remove moisture) into a round bottom flask. Rinse funnel thoroughly with hexane. Concentrate sample on vacuum rotary flask evaporator to 0.5 ml. Add sufficient hexane to obtain a 5 ml final volume.

6. Analytical Quality Control: The following procedures will be used to ensure the accuracy and precision of results. Detailed notes describing all quality control and analysis activities will be recorded.

- a. Fresh reagents and solvents will be used for all work performed.
- b. Glassware will be cleaned before and between analyses using the following steps: soap and water wash; deionized water rinse; methanol rinse; acetone rinse; and hexane rinse.
- c. Chlordane standards will be obtained from the Environmental Protection Agency and one commercial source and checked against one another. All standards will be marked with the date of receipt and the date opened.
- d. Concentrated stock standard solutions will be prepared, dated, marked with the initials of the individual preparing the standards, and stored in a freezer for no more than six months.
- e. Intermediate concentration standards will be prepared, dated, labeled as to concentration, marked with the initials of the individual preparing the standards, and stored in a freezer for no more than four months. These standards will be the source of the working standards.
- f. Working standards will be made up every three weeks, or more often if initial results for the standards differ by more than 5% from subsequent results. The working standards will be labeled with the date of preparation, initials of the individual preparing the standard, and the concentration of the standard.
- g. At the start of each day, one solvent blank and four standards will be run. One standard will be run again in the middle of the day, and again at the end of the day.
- h. Every 30th sample will be a spiked sample, which will be prepared according to the following: 0.5 ml of the intermediate standard is put into a flask with 50 ml of hexane. The spike is then concentrated down to 0.5 ml in the rotary evaporator as the real samples are.
- i. Duplicate injections will be made of every 20th sample. Remaining portions of the samples will be saved and stored in a locked freezer.

7. Reporting of Results

a. The analytical laboratory will track samples and report results using the first two letters and the last three digits of the sample number. For example, results from MC1945000002 would be reported as MC002. This will enable persons interpreting the results and making final calculations to refer directly to the data sheet number for all information pertaining to a given sample.

b. The analytical laboratory will report results in units of micrograms of chlordane in each sample. The agency collecting the samples should compute the sample results based upon the corrected volume of air sampled. The corrected volume should be calculated using the barometric pressure and inside temperature readings collected during the time the samples were collected.

EVALUATION OF RESULTS

The cost of corrective action to correct the problem of chlordane in the living environment makes it advisable to verify the validity of those air samples that are near the 5 microgram per cubic meter limit. Also, the cost of the sampling program makes it advisable to minimize the number of repeat samples that must be taken. Accordingly, the following criteria should be used.

1. For those samples that indicate a concentration of chlordane less than 3.5 micrograms per cubic meter, the quarters should be considered suitable for occupancy. No further sampling is necessary.

2. For those samples that indicate a concentration of chlordane greater than 6.5 micrograms per cubic meter. The quarters should be considered for corrective action to reduce the level of chlordane contamination. No further sampling is necessary until after this corrective action has been taken.

3. For those samples that indicate a chlordane concentration of 3.5 to 6.5 micrograms per cubic meter, resampling is suggested. Two additional samples should be collected using the procedures previously described. These samples should be collected at least 24 hours apart. The results of all three samples should be averaged and the resultant average value compared to the 5 microgram per cubic meter limit to determine the need for corrective action.

Chlordane Air Sampling
Collection Data Sheet

Installation _____ House Number _____
Sample Number _____ Date Collected _____
Sample Collected by _____
Sample location _____
Pump model & Serial No. _____ Collection medium _____
Time on _____ rotameter reading on/flow rate _____ /
Time off _____ rotameter reading off/flow rate _____ /
Sampling time _____ Average flow rate _____
Total air volume (m^3) _____
Inside temperature _____ Wet bulb temp _____ Rel Hum _____
Uncorrected barometric pressure (@ midpoint of sampling period) _____
Ambient temperature high _____ low _____
Analytical results (μg /sample) _____ $\mu g/m^3$ _____
Date treated for termites _____
Method of treatment _____
Insecticide used for termite treatment _____
Date shipped from sampling location _____
Date received at Service's Laboratory _____
Date shipped to contract laboratory for analysis _____
Date analyzed _____
Date analysis received _____

REMARKS:

Installation Commander

Chlordane Testing in Family Housing

Occupant

1. Many (a few) family housing units on (Installation) were treated with chlordane to prevent termite infestations. The chlordane was applied to the soil beneath the concrete foundation either before construction or after construction by injection through holes drilled in the foundation.
2. Recent tests at other military installations have shown that a small percentage of the homes treated in such a manner have measurable levels of chlordane in the interior atmosphere. It was determined that the chlordane had entered the interior through cracks in the heating ducts located in or beneath the slab.
3. To assess the magnitude of this potential problem, the (Component) is conducting air sampling in housing units that have been treated with chlordane and that have heating ducts in or beneath the concrete floor slab. Houses on (Installation) will be tested for chlordane during (Month). This test will consist of placing an electrically operated pump with a sampling device in your house and allowing it to run for two hours. Environmental Health (component or equivalent) personnel will be contacting you to arrange a convenient date and time for the test. We will try to keep the inconvenience to you at a minimum. You will be informed of the results of the tests when they are received.
4. (Name) is the project officer and (he/she) will answer any questions that you may have. (He/She) can be reached at (duty phone).
5. Thank you for your cooperation with this very important project.

SIGNED (Installation Commander)